2023 Scenathon results

FABLE Scenathon 2023: Pathways for food and land-use systems in Canada

FABLE CONSORTIUM

About FABLE
The Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium is a collaborative initiative to support the development of globally consistent mid-century national food and land-use pathways that could inform policies towards greater sustainability. The Consortium brings together teams of researchers from 24 countries and international partners from the UN Sustainable Development Solutions Network (SDSN), the International Institute for Applied Systems Analysis (IIASA), the Alliance of Bioversity International and CIAT, and the Potsdam Institute for Climate Impact Research (PIK). https://www.fableconsortium.org/

About the authors
The pathways for food and land-use systems in Canada were developed by René Reyes (UBC, Instituto Forestal de Chile), Hisham Zerrifi (University of British Columbia), Gregory Paradis (University of British Columbia), Avery Maloney (University of British Columbia).

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National context

Canada

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Our food and land-use systems are critical for staying within our planetary boundaries and the Earth's system resilience. Among the six Transformations required to achieve the Sustainable Development Goals (SDGs), the fourth Transformation—focusing on food, land, and water—is crucial. This Transformation is key to achieving SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 15 (Life on Land). Moreover, it significantly supports the remaining SDGs, underscoring its crucial role in fostering a sustainable future.

In this document, we present the results of the 2023 'Scenathon', a modelling exercise by the FABLE Consortium exploring three alternative futures for national and regional food and land-use systems. The term 'Scenathon' stands for 'a marathon of scenarios' and refers to FABLE's iterative process for ensuring that national and regional pathways have coherent trade assumptions and align with global sustainability targets (see the 2024 Sustainable Development Report for more information).

Through these long-term pathways, we can identify trade-offs and synergies between different goals and see the impact of various actions, as well as key levers for guiding sustainable development policies through 2030 and 2050. These results, together with our modelling tools and methods, are designed to support decision-making and the development of better policies and targets to drive the transformation of our food and land-use systems.

Figure 1. Historical share of GHG emissions from Agriculture, Forestry, and Other Land Use (AFOLU) to total AFOLU emissions and removals by source in 2020

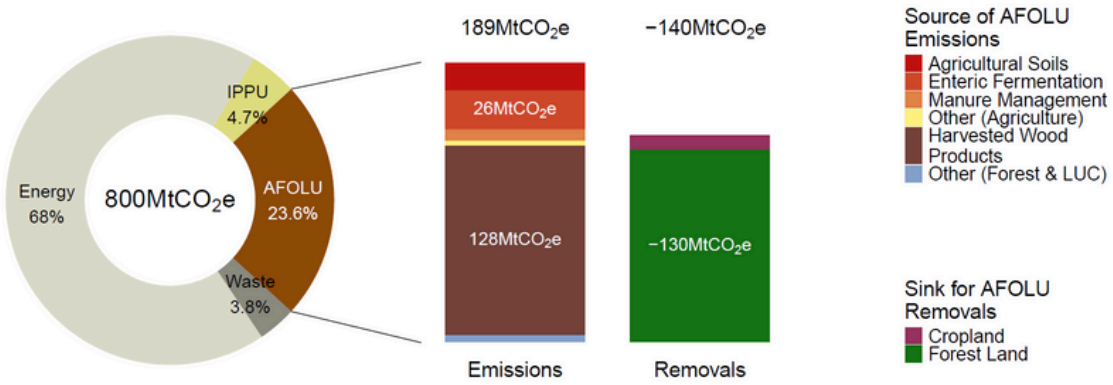
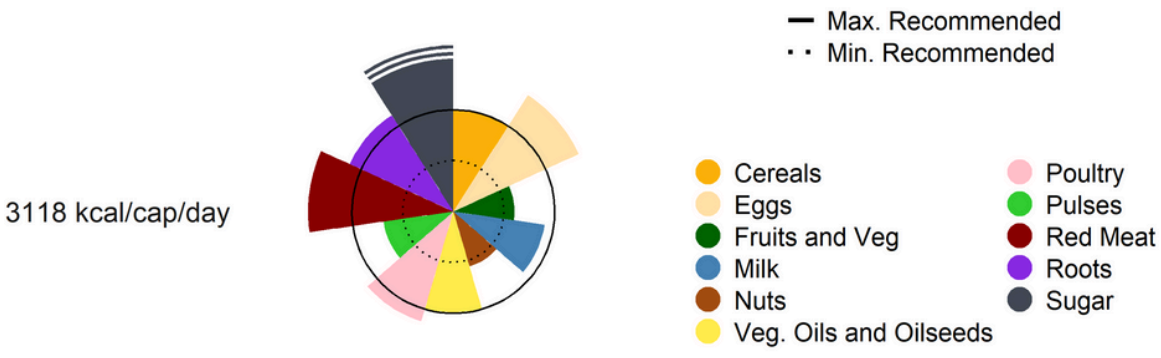


Figure 2. Daily average kilocalorie intake per capital per food category in 2020



National context

Canada

This table summarizes national targets for food and land use, derived from national commitments, policies, and strategies. It provides an overview of the country's current ambitions to transform its food and land-use systems. Where countries lacked quantitative national targets, we have estimated targets based on qualitative pledges.

SDG	Indicator	National Target
2 ZERO HUNGER	Undernourishment	By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons
	Diet-related disease	By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being
	Other food related targets	By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.
13 CLIMATE ACTION	Agriculture GHG emissions reduction	Canada's GhG emissions from agricultural practices remain unchanged by 2030
	Total GHG emissions reduction	By 2030, reduce Canada's total greenhouse gas emissions by 40 to 45%, relative to 2005 emission levels. By 2050, achieve economy-wide net-zero greenhouse gas emissions.
	Land use and land use change GHG emissions reduction	Canada increases net GhG emission removals from LULUC related to Agricultural Land use by 172% by 2030
	Reduce or halt deforestation	Halt and reverse forest loss and land degradation by 2030
15 LIFE ON LAND	Expand protected areas or 'Other effective area-based conservation measures' (OECMs)	Conserve and protect 30% of lands by 2030. Restoration of addtional 30% of degraded habitats and ecosystems by 2030.
	Promote afforestation	2 Billion Trees program by 2031
14 LIFE BELOW WATER	Water related targets	All of the long-term drinking water advisories on public systems on Indigenous reserves are resolved.
	Limit nitrogen and phosphorus use	Reduce emissions from fertilizer application by 30% below 2020 levels by 2030

Model

Using the open-access FABLE Calculator and the FABLE decentralized modelling infrastructure, we have developed three alternative pathways —Current Trends, National Commitments, and Sustainable Pathway— to explore the impact of various practices and policies on achieving sustainability targets through 2050. We compare our results with targets across food security and nutrition, GHG emissions reduction, forest and biodiversity conservation, and sustainable use of water, nitrogen, and phosphorus.

For each of these pathways, we have established various assumptions regarding the evolution of several model parameters. These parameters include population growth, dietary patterns, food waste, food import and export levels, crop and livestock productivity, agricultural expansion, afforestation, livestock density, protected areas expansion, post-harvest losses, biofuel demand, urban expansion, agricultural practice coverage, and irrigation area expansion. These assumptions detail the extent to which these factors will drive changes in food and land systems from 2020 to 2050.

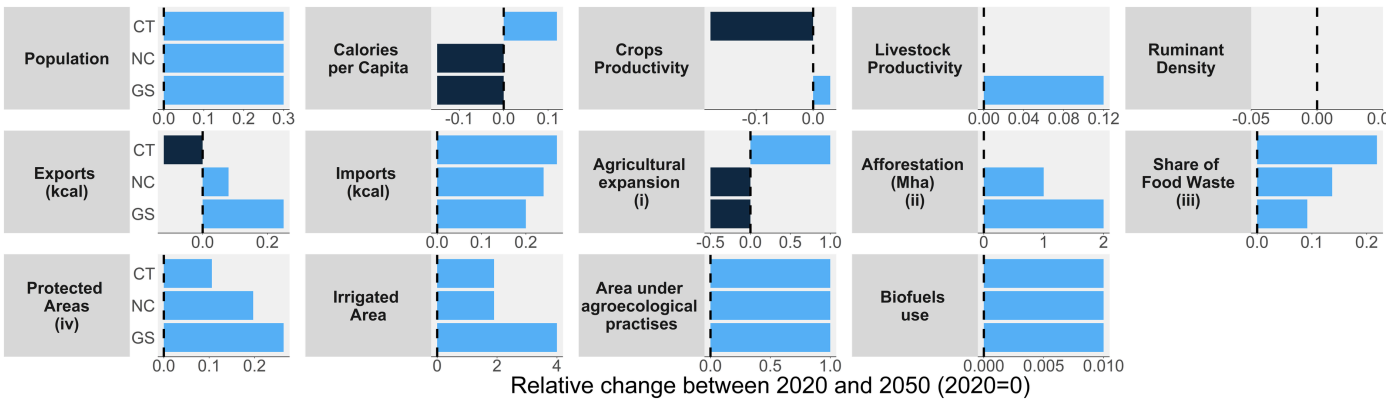
Pathway narratives

Current Trends: Canada is not committed. Agricultural expansion, increased deforestation, reduced crop yields, and people's diets based on animal protein and ultra-processed foods.

National Commitments: Canada tries, but is not enough: Limited agricultural expansion, no deforestation beyond 2030, some afforestation, and healthier diets. Crop yields remain similar to current levels.

Global Sustainability: Canada works harder: Limited agricultural expansion and more organic production, no deforestation beyond 2030, higher afforestation and biodiversity protection (including Indigenous initiatives), healthier diets, and higher crop yield and exports (despite a reduced consumption of fertilizer).

Figure 3. Assumptions on the levers for change in each pathway



Notes: (i) Results are expressed in code, taking the value 1 for 'Free expansion scenario', -0.5 for 'No deforestation' and -1 for 'No Agricultural expansion'.
(ii) Results are expressed in a net increase rather than relative change.
(iii) Results are expressed % of consumption that is wasted.
(iv) Results are expressed in % of total land in 2050.

Figure 4. Computed daily average intake per capita over 2000-2050

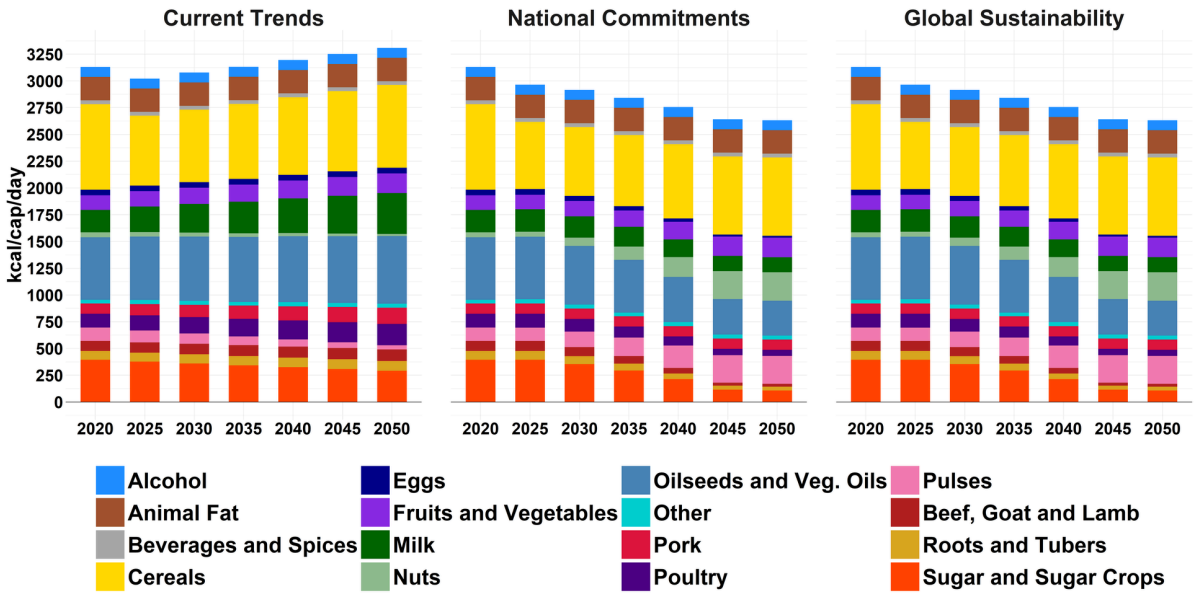


Figure 5. Comparison of the computed daily average kilocalorie intake per capital per food category across the three pathways and the prevalence of undernourishment in 2050

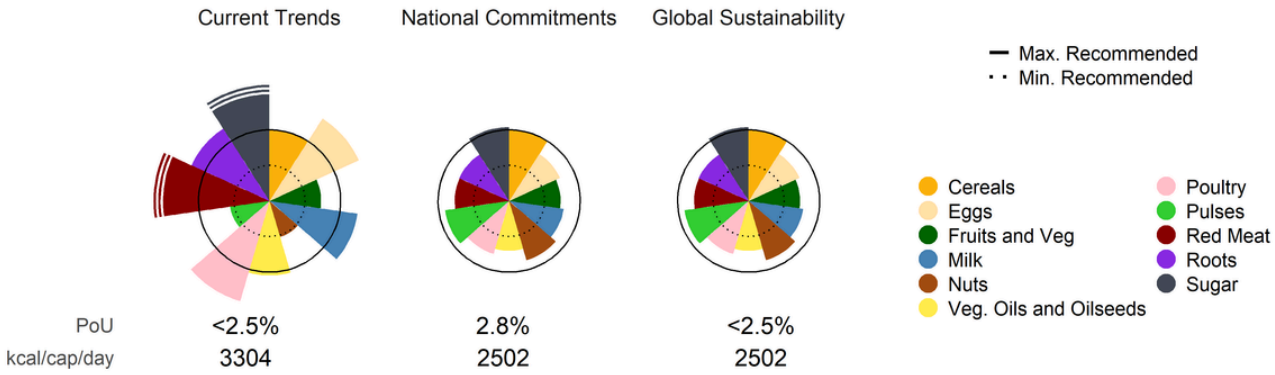


Figure 6. Evolution of land cover 2000-2050

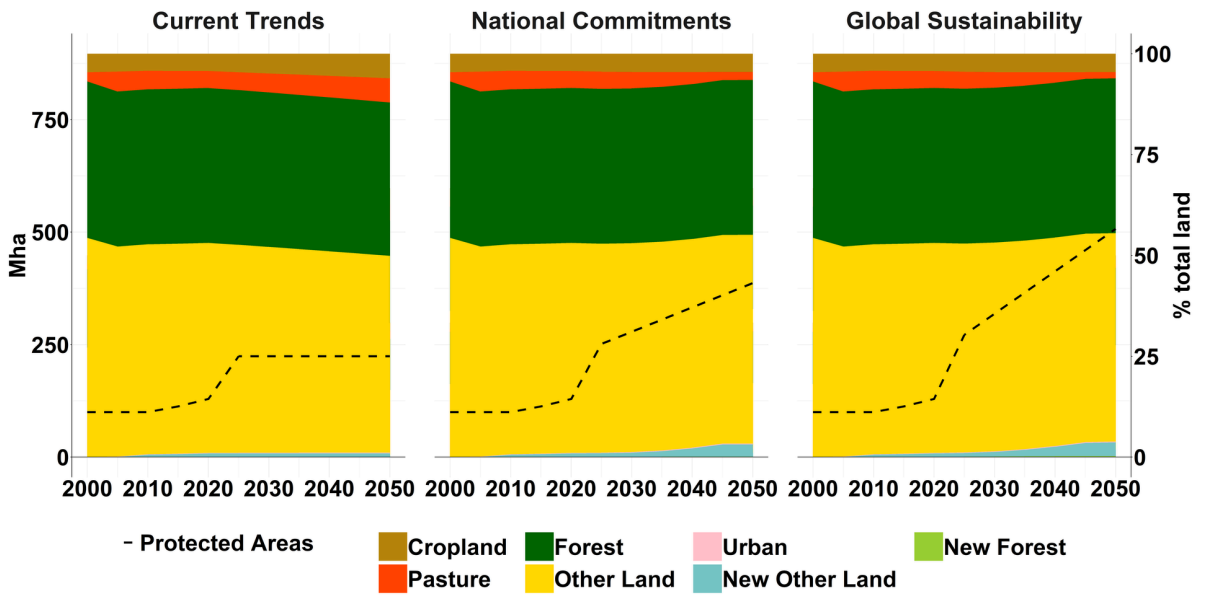


Figure 7. Evolution of the cropland composition 2000-2050

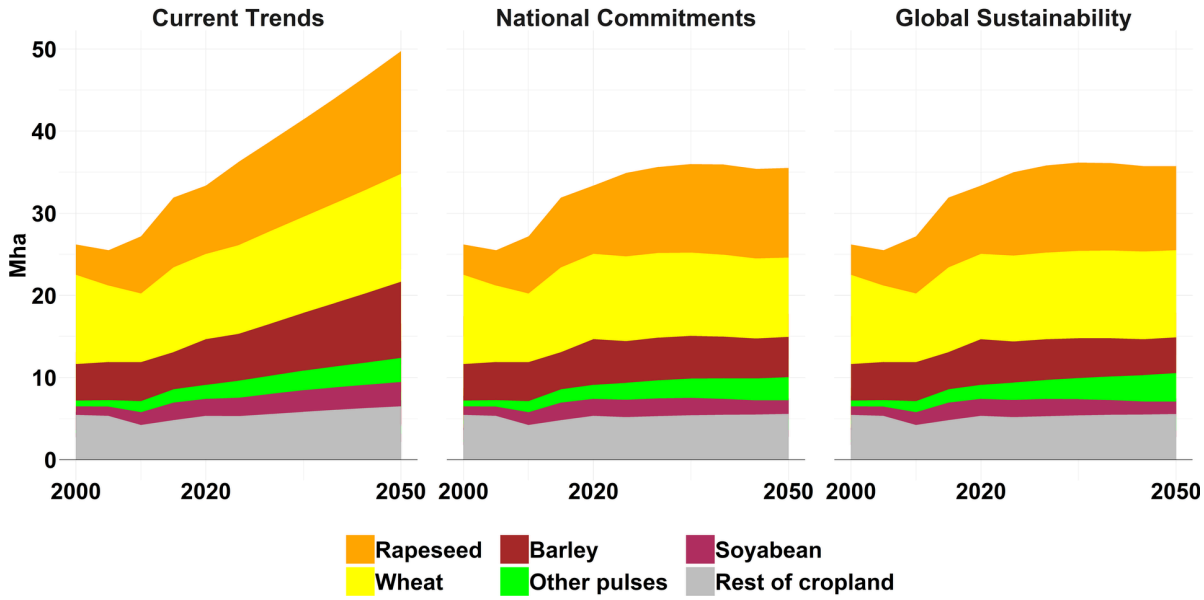


Figure 8. Projected AFOLU emissions and removals between 2020 and 2050 by main sources and sinks across pathways

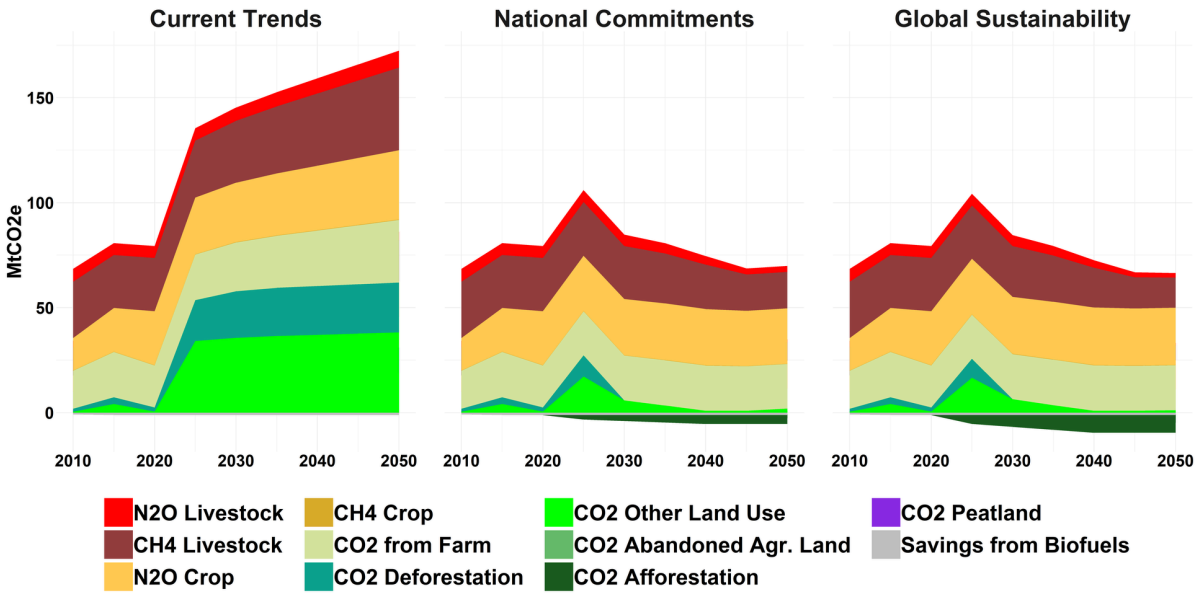
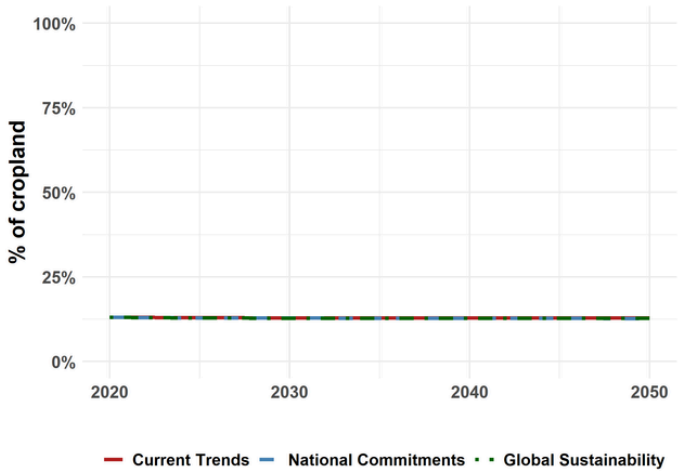


Figure 9. Share of cropland under agroecological practices



Agroecological practices included: Cover crops, cultivar mixtures, diversified farming systems, embedded natural, organic farming, no/minimal tillage.

Figure 10. Total area of land where natural processes predominate (LNPP)

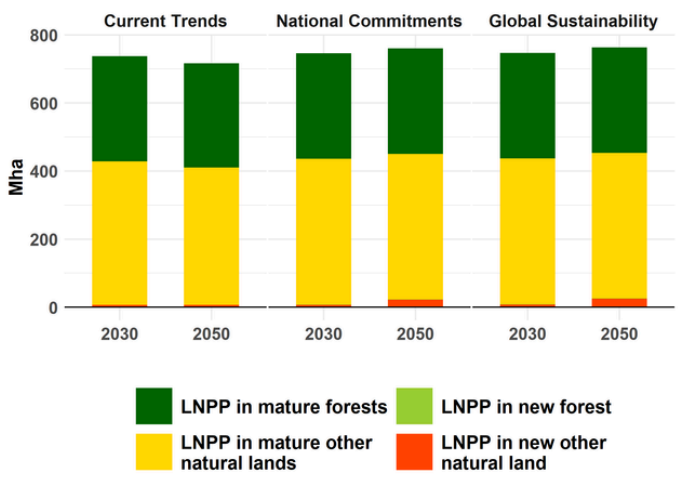


Figure 11. Nitrogen application

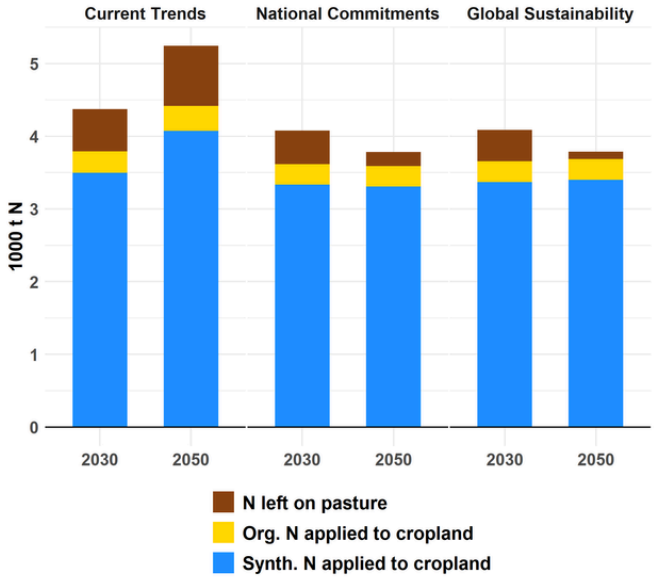
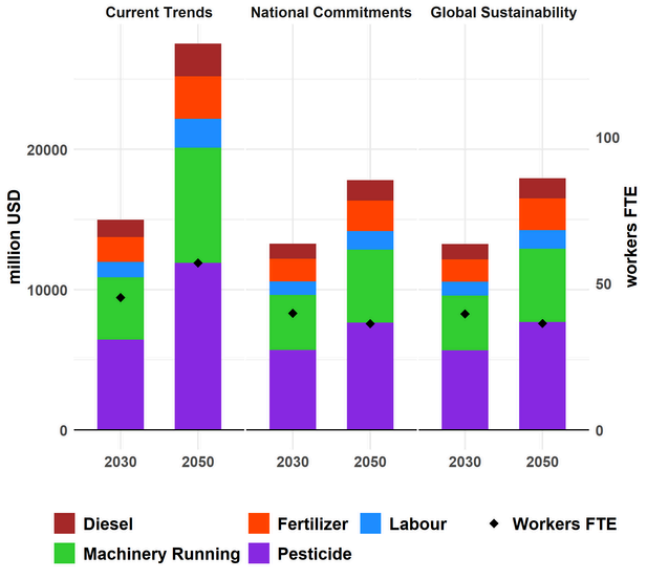


Figure 12. On farm production costs



FTE: Full-time equivalent

For more detailed results and visual data, visit www.scenathon.org

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
1. Macroeconomics	**1.1)** GDP per capita	Canadian GDP would increase by 1,5% annual by 2050 (SSP1).	Same as CT.	Same as CT.	OECD (2021)
	1.2) Population	49 million inhabitants in 2050 (UN_high).	Same as CT.	Same as CT.	Statistics Canada (2023).
	1.3) Inflation	Increase by 194% between 2020 and 2050, which equals to 3.8% of average annual inflation.	Same as CT.	Same as CT.	World Bank (2023)
	1.4) Inequalities	Inequality has remained stable in Canada in the last 25 years, we assume this will continue following the same trend in the coming decades.	Same as CT.	Same as CT.	Burkinshaw et al. (2022)
2. Land	**2.1)** Constraints on agricultural expansion/deforestation	No constraints for agricultural expansion beyond protected areas. Our estimates indicate that, under current land-use trends, agricultural land could expand by 2050, with 31% of new agricultural lands come from deforestation.	Agriculture expansion does not drive deforestation beyond 2030, as new policies ban land use changes that negatively affect forests.	Same as NC.	Using ESA (2010) and UNEP-WCMC & IUCN (2020) for current trend, and Canada's Protected Areas (2019)
	2.2) Afforestation, and forest plantations targets	By 2030, no afforested lands and naturally regenerated areas (restoration) are gained. No federal goals for afforestation.	By 2030, 1 Mha of commercial timber plantations and 1 Mha of naturally regenerated forests on abandoned agricultural lands and pastures are gained. Programs like the Caribou Habitat Restoration Project, Afforestation	By 2030, 2 Mha of commercial timber plantations and 2 Mha of naturally regenerated forests on abandoned agricultural lands and pastures are gained. Programs like the Caribou Habitat Restoration Project, Afforestation	Government of Ontario (2017), Habitat Conservation Trust Foundation (2020) and Tree Canada (2020).

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
			Ontario, and the National Greening Program are promoting afforestation on degraded lands as a way to recover ecosystem services, and timber production.	Ontario, and the National Greening Program are promoting afforestation on degraded lands as a way to recover ecosystem services, and timber production.	
	2.3) Urban and settlements area	Urban areas represent about 0.13% of total lands in Canada by 2020, which could increase to 0.20% in 2050.	Same as CT.	Same as CT.	Angel et al. (2011).
	2.4) Protected areas	11% of total area by 2030. The "other effective area-based conservation measure", which is considered in the Canadian strategy to reach the Aichi Biodiversity Target, could be ineffective to protect ecosystems, as national parks and other formal protected areas do. This would not increment the share of the terrestrial ecosystems under protection.	23% of total area by 2030. New provincial and national protected areas, and Indigenous conservation areas will significantly increase the share of formally protected areas in Canada.	30% of total area by 2030. New provincial and national protected areas, and Indigenous conservation areas will significantly increase the share of formally protected areas in Canada.	MacKinnon et al. (2015); Lemieux et al. (2019).
3. Productivity and management	**3.1)** Crop productivity for the key crops	Between 2020 and 2050, a lower use of fertilizer and negative impacts of climate change will reduce main crops productivity: -from 3.4 t/ha to 2.8 t/ha for wheat	Between 2020 and 2050, most main crop productivities remain: -from 3.4 t/ha to 3.7 t/ha for wheat -from 2.3 t/ha to 2.3 t/ha for rapeseed	Between 2020 and 2050, a lower fertilizer consumption but positive impacts of climate change (longer growing season and better temperatures), and improved agricultural practices, better seeds,	Based on USDA (2023a) for current trend, and Hannah et al. (2020), Krishna et al. (2021) and Williams et al. (2021) for other scenarios; and expert consultations.

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		-from 2.3 t/ha to 1.6 t/ha for rapeseed -from 3.8 t/ha to 3,3 t/ha for barley -from 3.0 t/ha to 2.5 t/ha for soybeans -from 1.9 t/ha to 1.5 t/ha for pulses	-from 3.8 t/ha to 3.8 t/ha for barley -from 3.0 t/ha to 3.0 t/ha for soybeans -from 1.9 t/ha to 1.8 t/ha for pulses	etc. will increase main crops productivity: -from 3.4 t/ha to 3.9 t/ha for wheat -from 2.3 t/ha to 2.4 t/ha for rapeseed -from 3.8 t/ha to 3,9 t/ha for barley -from 3.0 t/ha to 3.4 t/ha for soybeans -from 1.9 t/ha to 1.8 t/ha for pulses	
	3.2) Cropland under agroecological practices	2% of total cropland under agroecological practices by 2030. In Canada, "organic farming" is the concept used to refer to more sustainable practices in agriculture.	Same as CT.	Same as CT.	Isaac et al. (2018). National commitment was assumed in order to achieve a net reduction of 3% on GHG emissions from agricultural practices by 2023.
	3.3) Livestock productivity for the key livestock products	Between 2015 and 2050, the productivity per head remains: -from 438 kg/head to 438 kg/head for beef production -from 100 kg/head to 100 kg/head for pork production -from 23.8 L/day by dairy cow to 23.8 L/day -from 2.5 kg/head by chicken to 2.5 kg/head	Same as CT.	Between 2015 and 2050, the productivity per head increases: -from 438 kg/head to 480 kg/head for beef production -from 100 kg/head to 112 kg/head for pork production -from 23.8 L/day by dairy cow to 26.6 L/day -from 2.5 kg/head by chicken to 2.8 kg/head	USDA (2023a, 2023b)
	3.4) Pasture stocking rate	It remains from 0.76 head of grazed cattle/ha to 0.76 head of grazed cattle/ha	Same as CT.	Same as CT.	Statistics Canada (2005), Thorpe et al. (2008)

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		of pasture between 2005 and 2050.			
	3.5) Forest management	85% of logged forests are clear-cut through the whole period (there are no tree crops in Canada).	Same as CT.	Same as CT.	Statistics Canada (2017), Thorpe et al. (2008)
4. Trade	**4.1)** Share of consumption which is imported for key imported products (%)	The share of total consumption which is imported stays constant for corn, sugar, orange, and vegetables	Same as CT.	Same as CT.	Assumed
	4.2) Evolution of exports for key exported products (1000 tons)	Exports will mostly - decrease, driven by lower productivities in the agro-food sector. -decrease from 26 Mt 2020 to 17 Mt in 2050 for wheat -decrease from 11,8 Mt 2020 to 9,8 Mt in 2050 for rapeseed -remain from 4,0 Mt 2020 to 4,0 Mt in 2050 for soybeans -increases from 1,3 Mt 2020 to 2,1 Mt in 2050 for pork -increases from 3,1 Mt 2020 to 3,9 Mt in 2050 for pulses -decreases from 3,3 Mt 2020 to 2,0 Mt in 2050 for barley	Exports will decrease for some products, and increase for others: -decrease from 26 Mt 2020 to 21,3 Mt in 2050 for wheat -increases from 11,8 Mt 2020 to 16,4 Mt in 2050 for rapeseed -increases from 4,0 Mt 2020 to 4,9 Mt in 2050 for soybeans -increases from 1,3 Mt 2020 to 2,1 Mt in 2050 for pork -increases from 3,1 Mt 2020 to 4,4 Mt in 2050 for pulses -decreases from 3,3 Mt 2020 to 2,5 Mt in 2050 for barley -decreases from 15,2 Mt 2020 to 13,2 Mt in 2050 for pulp	Exports will mostly increase, driven by higher productivities in the agro-food sector: -Increase from 26 Mt 2020 to 29,6 Mt in 2050 for wheat -increases from 11,8 Mt 2020 to 19 Mt in 2050 for rapeseed -increases from 4,0 Mt 2020 to 5,4 Mt in 2050 for soybeans -increases from 1,3 Mt 2020 to 2,1 Mt in 2050 for pork -increases from 3,1 Mt 2020 to 5 Mt in 2050 for pulses -decreases from 3,3 Mt 2020 to 3 Mt in 2050 for barley	Based on USDA (2023a) and FAOSTAT (2023) for current trends, and Advanced Biofuels Canada (2019), Beckman and Nigatu (2017), Taylor (2017b), and dos Santos et al. (2018) for other scenarios

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		-decreases from 15,2 Mt 2020 to 15,0 Mt in 2050 for pulp -decreases from 25,4 Mm3 2020 to 20,5 Mm3 in 2050 for sawn wood conifers	-decreases from 25,4 Mm3 2020 to 24 Mm3 in 2050 for sawn wood conifers	-increases from 15,2 Mt 2020 to 16,8 Mt in 2050 for pulp -increases from 25,4 Mm3 2020 to 27,1 Mm3 in 2050 for sawn wood conifers	
5. Food	**5.1)** Average dietary composition	By 2050, the average daily calorie consumption per capita is 3310 kcal and composed as: 26% cereals, 13% dairy, 4% red meat, 14% other meat, 21% oil and fat, 10% sugar, 7% fruits and vegetables, 1% pulses, 3% others.	By 2050, the average daily calorie consumption per capita is 2,475 kcal and composed as: 29% cereals, 6% dairy, 1% red meat, 6% other meat, 13% oils and fat, 4% sugar, 20% fruits and vegetables, and 11% pulses, and 10% others. People reduce ultra-processed food consumption and red meat and increase seeds and vegetables. Educational programs and other initiatives to promote healthier lifestyles have a significant impact on Canadians.	Same as NC.	Based on Willett et al. (2019) for national commitments and sustainable pathway.
	5.2) Share of food consumption which is wasted at household level	Remain by 2050 in comparison to 2020 level	Reduced by 30% in comparison to 2020 level.	Reduced by 50% in comparison to 2020 level.	Food Waste Reduction Challenge (2020)
6. Biofuels	**6.1)** Targets on biofuel and/or other bioenergy use	Biofuel demand (including renewable diesel) accounts for 27% corn production, and 2% of wheat, canola and soy	Biofuel demand (including renewable diesel) accounts for 27% corn production, and 2% of wheat, canola and soy production by 2025, and it	Same as NC.	Canada's Action Plan for Clean On-Road Transportation (2022)

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		production by 2025, and it remains increasing.	stabilizes afterwards as a result of EVs. Ethanol use in cars will go down, but biofuel demand for aviation and marine shipping will go up sharply.		
	6.2) Targets on other non-food use	The demand for non-food used products remains stable between 2020 and 2050.	Same as NC.	Same as NC.	Canada´s bioeconomy strategy (2019)
7.Water	**7.1)** Irrigated crop area	Increase by 90% between 2020 and 2050.	Same as CT.	Increase by 300% between 2020 and 2050.	Based on Statistics Canada (2021)